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VARIETAL DIFFERENCES IN THE RESISTANCE OF CABBAGE AND LETTUCE TO LOW TEMPERATURES

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There is a limiting zone of temperature for each of our crop plants beyond which it can not be grown without danger of failure from freezing. The temperature zones of our country are well known, and in many States the dates of earliest and latest frosts, as well as the minimum winter temperature, have been charted for a number of years. The temperature limits for the varieties of crop plants are by no means so well known. Most of our information is based upon the experience and opinion of farmers, and no accurate data are available on the low temperature limits which ordinary crops can withstand. The opinions of expert horticulturists vary greatly concerning the relative frost resistance of our most common varieties of garden vegetables.

Plants which do not withstand freezing of their tissues are limited to temperatures above their freezing points, but numerous important crops can withstand freezing if they are previously hardened. Small differences in the rate of hardening may determine the survival of varieties. It was the purpose of this study to determine if varietal differences in hardiness can be placed on an exact basis.

The winter resistance of cabbage and lettuce varieties has become of importance owing to their increased use as salad plants in early spring, and also on account of the gradual northward trend of the area over which they are grown in winter for the spring market. Studies on nutrition have shown that fresh green vegetables are necessary articles of diet. It is therefore desirable to have fresh salad plants available during as great a part of the year as possible. Every one is acquainted with the craving for "greens" in the spring. This craving is a sure indication of the insufficient use of these foods during the winter. The most effective way to supply this need is to produce salads for use in early spring. Cabbage and lettuce are especially adapted for this purpose on account of their high yield per acre and good keeping qualities which make them available at prices which can be afforded by all classes in contradistinction to greenhouse grown salads. Cabbage is a better keeper than lettuce and can be marketed in better condition, but it is highly desirable to have salads which will be used uncooked, and for this purpose lettuce is the favorite. The Chinese cabbages are very desirable for use as fresh salads, but unfortunately they are more susceptible to frost than ordinary cabbage. Some breeding must be done upon them before they can be made available for general use. Frequently cold winters such as occurred in 1919–1920 have caused heavy losses in the winter-grown cabbage crop in the region about Norfolk, Virginia. The loss during that winter has been estimated at one half of the crop. It seemed desirable, therefore, to make accurate tests of the relative frost resistance of cabbage and lettuce varieties.

Practical experience has shown that only a few varieties of cabbage are adapted for fall planting. In the Norfolk region the Jersey Wakefield and the closely related Charleston Wakefield have been found superior in winter resistance. Trials were made to determine the reasons for this superiority in winter resistance and to test out the relative importance of some of the factors concerned in hardiness. It was considered desirable also to find if there are varietal differences in hardiness which can be expressed with exactness.

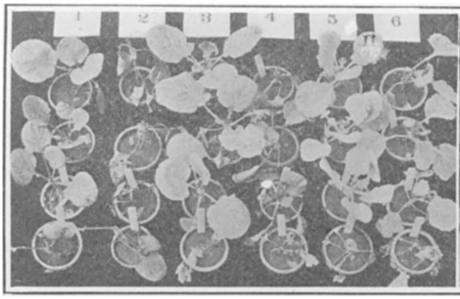

FIG. 1. Hardened 5 days at 5° C. Frozen 5 hours at —5° C. Front row greenhouse checks. No. 1, Mammoth Red; 2, Danish Stone Head; 3, Early Jersey Wakefield; 4, Zittauer; 5, Danish Ball Head; 6, Early All Season.

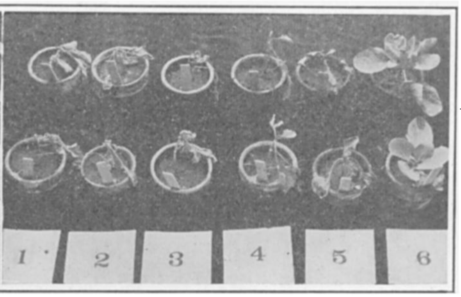

FIG. 2. Hardened 5 days at 0° C. Frozen 12 hours at —6.6° C. No. 1, Savoy; 2, Charleston Wakefield; 3, Danish Ball Head; 4, All Season; 5, New Early Succession; 6, Early Jersey Wakefield.

Field trials with plants in the open are undoubtedly valuable for the selection of winter resistant strains. But plants in the field have many factors to contend with, such as desiccation in the frozen condition, smothering from ice, and many other factors. It is therefore almost impossible to test out in the field small variations in any single factor such as differences in ability to harden. Furthermore, it is only seldom that temperatures are obtained which are of the proper range to make evident the differences in hardiness. The winter may be too mild to kill any variety, or it may kill all varieties. By using artificially controlled temperatures one can eliminate the action of many factors which would confuse the results of field trials. Also, one can adjust the temperature so as to select those plants which have a desired hardiness.

The author has used in this work four constant temperature chambers in which accurate temperature control was secured by electrical means, and low temperatures established by refrigeration. The chambers were provided for light exposure of the plants so that etiolation did not occur during the hardening period. Care was taken to eliminate differences in exposure of the plants.

There are undoubtedly many factors concerned in the ability of cabbages to survive the winter; but, above all, the changes which occur in the proteins whereby they are prevented from precipitating upon freezing is of the most importance. (I) Changes in the sugar content causing increased depression of the freezing point, or changes in the leaf coverings which aid undercooling of the tissue, are of less importance. (II) Red cabbages generally have a higher sugar content than the green varieties, with consequently greater depression of the freezing point. For this reason red cabbages do not freeze as quickly as green varieties, and unhardened red plants are not injured as easily as green cabbages which have been grown at the same temperature. But not all red cabbages harden well; that is, when exposed to temperatures somewhat above their freezing points, some red varieties do not acclimatize themselves to the low temperatures as quickly as some of the green varieties. This shows that the sugar content is not the deciding factor in frost resistance. The front row of plants shown in figure 1 are greenhouse controls and show the amount of injury to unhardened plants. The greenish-red Zittauer cabbage (No. 4, figure 1) does not harden as well as Red Danish Stone Head (No. 2, figure 1), and both of these are injured more than Early All Season (No. 6, figure 1), a green cabbage. The Mammoth Red variety (No. 1, figure 1) has a low freezing point at start and also hardens well, making it well adapted for winter resistance. Some green cabbages harden well, although they show but little frost resistance in the unhardened condition. This ability to harden is shown well by Jersey Wakefield (No. 3, figure 1) and Danish Ball Head (No. 5, figure 1). All plants shown in this photograph were of the same age and size. Except for those in the front row, they

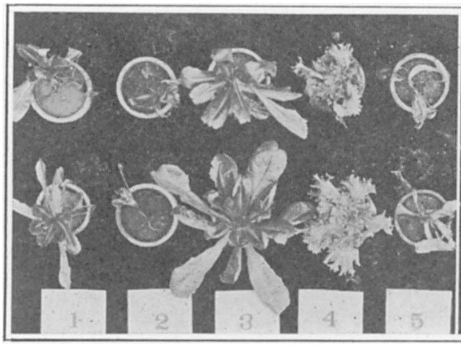

FIG. 3. Hardened 5 days at 3° C. Frozen 5 hours at —4.1° C. No. 1, Dreer All Heart; 2, Kingsholm Cos; 3, Hicks Hardy Winter Cos; 4, Boston Curled; 5, Hanson.

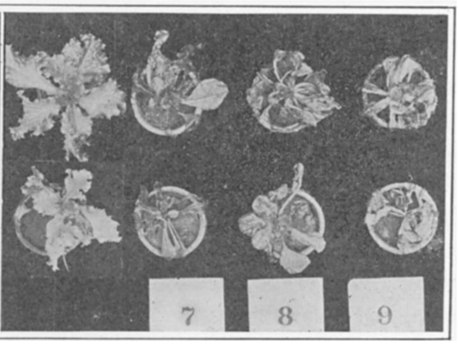

FIG. 4. Hardened 5 days at 3° C. Frozen 5 hours at —4.1° C. No. 6 (not numbered), Grand Rapids; 7, Brittle Ice; 8, Market Gardeners Private Stock; 9, Golden Queen.

were all given the same treatment throughout. After growing to suitable size in the greenhouse at 60–65° F. (15.5–18° C.), those in the three upper rows were hardened in a constant temperature compartment for 5 days at 5° C. They were then placed with the controls from the greenhouse at —5° C. and allowed to freeze for 5 hours. They were then replaced in the greenhouse and allowed to stand for a few days so that differences in injury might become evident. The trials were repeated several times and effects were obtained essentially as shown in the photograph. In the series shown in figure 2 the plants were hardened for 5 days at 0° C. and frozen for 12 hours at —6.6° C. Under this more severe treatment the superiority of Jersey Wakefield (No. 6, figure 2) became evident. Greenhouse controls were all killed under these conditions.

Tests were made upon the Paoting, Peking, Shantung, Chosen, and Chokurei varieties of Chinese cabbage, but no differences in hardiness which would be of commercial value were discovered. The Paoting and Peking varieties seemed a little more susceptible to frost than the other varieties which have a tougher cuticle and whose leaves are less succulent. All of these Chinese cabbages are more susceptible to frost than the ordinary species of cabbages and do not harden well.

Tests were run upon lettuce to determine if varietal differences in hardening capacity exist in this group of plants also. In the fifty or more varieties of lettuce commonly grown by seedsmen a very great range of hardiness was shown. Many of these varieties are but little different in hardiness. In the photographs shown here selections were made of varieties which showed some contrast in their reaction to low temperatures. The order of injury for several varieties was found the same by numerous tests. Hence it is not necessary to put all plants of a great number of varieties under test at the same time. The relative order of hardiness can be established by placing a few indicator plants in each test. Usually two or three varieties which showed a range of hardiness were used as indicators, such as the very hardy Hick's Hardy Winter Cos and the less hardy Kingsholm Cos. From the amount of injury to such indicator plants in comparison with others in the series one can then make comparison between series.

In figures 3 and 4 the plants were hardened 5 days at 3° C. and exposed at —4.1° C. for 5 hours. Here Kingsholm Cos (No. 2, figure 3) is much more injured than Dreer's All Heart (No. 1, figure 3). Two curled varieties, Boston Curled (No. 4, figure 3) and Grand Rapids (No. 6, figure 4), hardened well. The order of increasing injury in this series is therefore:

> Hicks Hardy Winter Cos < Boston Curled < Dreer's All Heart = Grand Rapids < Kingsholm Cos = Market Gardeners Private Stock < Golden Queen = Brittle Ice = Hanson.

In the tests shown in figures 5 and 6 all the plants were hardened for

3 days at 3° C., a very short period, except the first row, which consists of controls from the greenhouse. They were exposed to —4.7° C. for 3 hours. From the first row of controls it is seen that Hicks Hardy Winter Cos (No. 1, figure 5) and Boston Curled (No. 1, figure 6) possessed considerable original hardiness. That is, they seem able to withstand the low temperature exposure without the preliminary hardening treatment. They are resistant to freezing, although grown at 55–60° F. (12.8–15.6° C.) in the greenhouse. The order of injury after hardening and freezing in this series is Hicks Hardy Winter Cos < Boston Curled = Wayahead = Defiance < Market Gardeners Private Stock = Kingsholm Cos < Giant White Cos. The order of injury is about the same as in the previous series. Some irregularities were observed such as the greater injury to one Boston Curled plant (No. 1, figure 6), the reason for which is not apparent. By making comparison between greater numbers of plants of each variety than are shown in this photograph these individual differences could be averaged. With the size of chambers used this would have limited the number of varieties to two or three for each test.

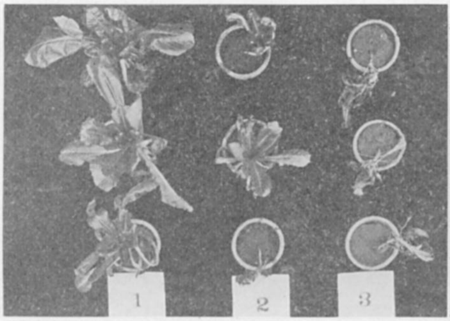

FIG. 5. Hardened 3 days at 3° C. Frozen 3 hours at —4.7° C. Front row controls. No. 1, Hicks Hardy Winter Cos; 2, Kingsholm Cos; 3, Giant White Cos.

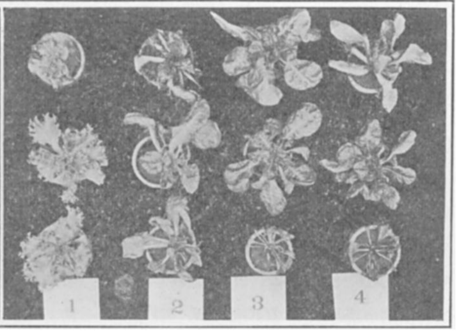

FIG. 6. Hardened 3 days at 3° C. Frozen 3 hours at —4.7° C. Front row controls. No. 1, Boston Curled; 2, Market Gardeners Private Stock; 3, Wayahead; 4, Defiance.

DISCUSSION

It is evident from the data here presented that we have a valuable means of accurately determining the ability of plants to harden. The author believes that this method ought to be used in breeding work in which hardiness is the character desired. The method will undoubtedly allow the selection of those members of a cross which possess the desired degree of hardiness. Furthermore, small differences in hardiness can be detected which would not be noticed in field trials. By making use of artificially controlled temperatures it is not necessary to wait through a period of years to determine the hardiness of varieties.

It is suggested by this data, and from previous work, that the ability to become immune to freezing at a given temperature is an expression of varietal differences in the protein constituents of the protoplasm. This property is not dependent upon the tendency of the variety to produce sugars which tend to decrease the precipitation of proteins on freezing. Cases have been mentioned in which high sugar content of a red cabbage did not render it less susceptible to freezing than green cabbages with less sugar; and, on the contrary, cases are given in which plants with low sugar content were more capable of hardening than those with high sugar content.

SUMMARY

An exact method for testing the ability of plants to harden is given and applications for it are suggested.

Using this method, the relative injury to varieties of cabbage and lettuce at low temperatures is shown to be dependent upon varietal differences in the ability of these plants to harden.

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